



Extreme Universe Space Observatory (EUSO) Optics Module

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US Collaboration Roles

| Institution | | Optic Sub-System Roles |
|---------------------------------------|--|---|
| MSFC/NASA | | Analysis, Simulation, Testing, Structure and Environmental |
| Univ. of Alabama in Huntsville | | Design, Analysis and Testing |
| Univ. of Arizona | | Integration, Focusing Algorithm |
| | | |
| | | Other Roles |
| MSFC/NASA | | Management, Simulations, GLS, Data Analysis |
| U of Alabama in Huntsville | | Theory, Simulations, Data Analysis |
| Vanderbilt | | Theory, Simulations, Data Analysis |
| UCLA | | Simulations, Atmosphere, Theory, Data Analysis |
| UCB | | Simulations, EP/O, Data Analysis |

Status of Optic System Work

- Testing

- Measurement of the spectral refractive index on PMMA prism (UAH, Geary)
- Measure homogeneity of CYTOP plate (UAH, Geary)

- Test Facility

- Evaluate the AMOR facility and make a preliminary measurement of the spectral reflectivity of the AMOR in the deep blue (UAH, Reardon)

- Manufacturing

- Diamond turned copper mold for subscale model for manufacturing Fresnel Lens (UAH, Blackwell)

- Mechanical Structure

- Focusing mechanism and algorithm (MSFC/UA)

- Anti-reflective Coating

- SBIR contract to test and demonstrate new technique for achieving antireflective coatings that will adhere to PMMA with good performance in the UV

Plans for Optic System

- Complete ongoing tasks with remaining funds
- Support testing to raise TRL level

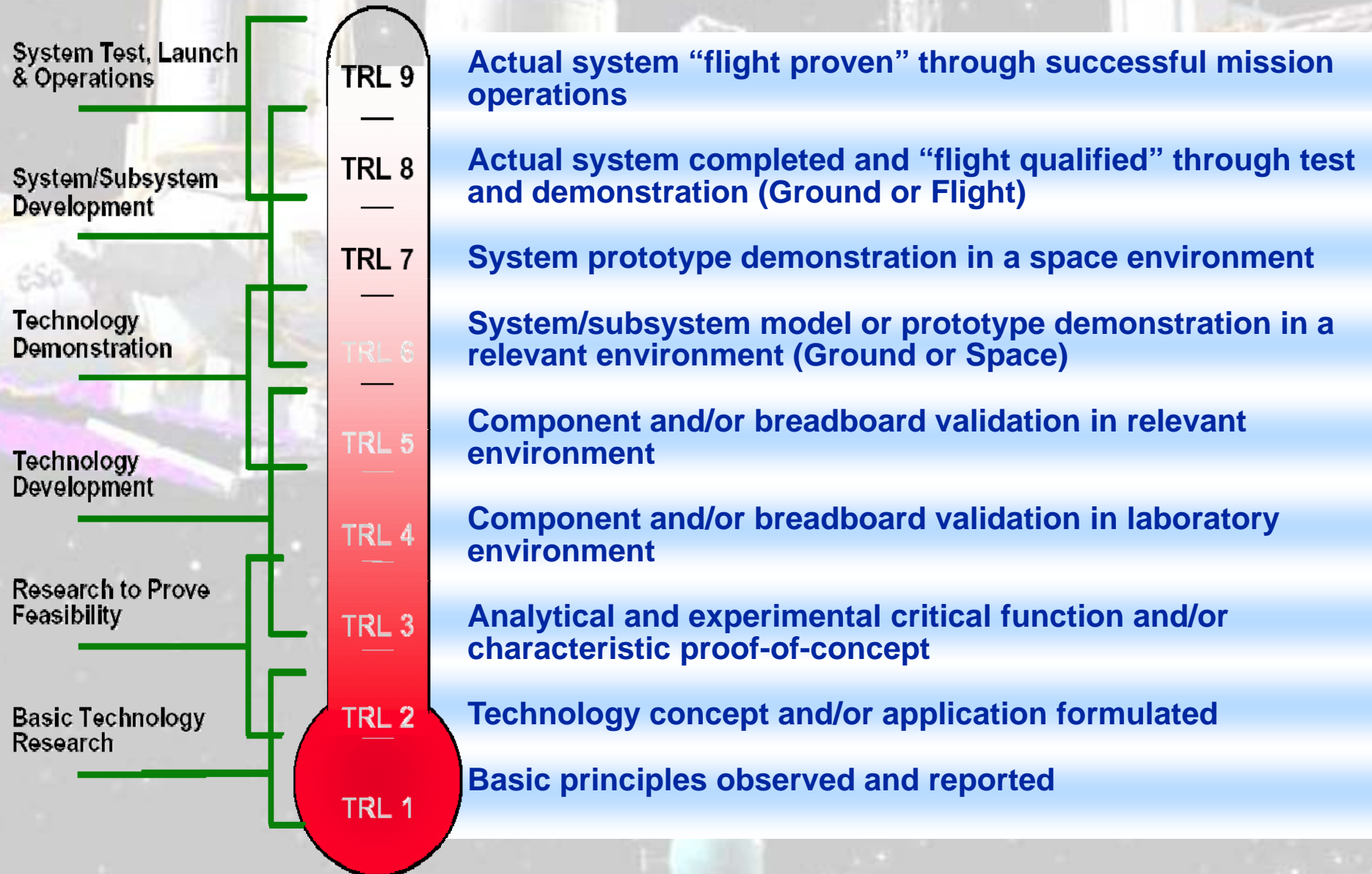
Test subscale model of complete central optic (Riken)

- Full aperture optical test with focal plane detector (TBD)

Evaluate manufacturing precision

- Annulus includes a 2.5m diameter that are representative of the Fresnel facets and micro-grating structure
- For both annulus and subscale optic:
 - Verify groove placement and repeatability
 - Facet figure
 - Surface roughness

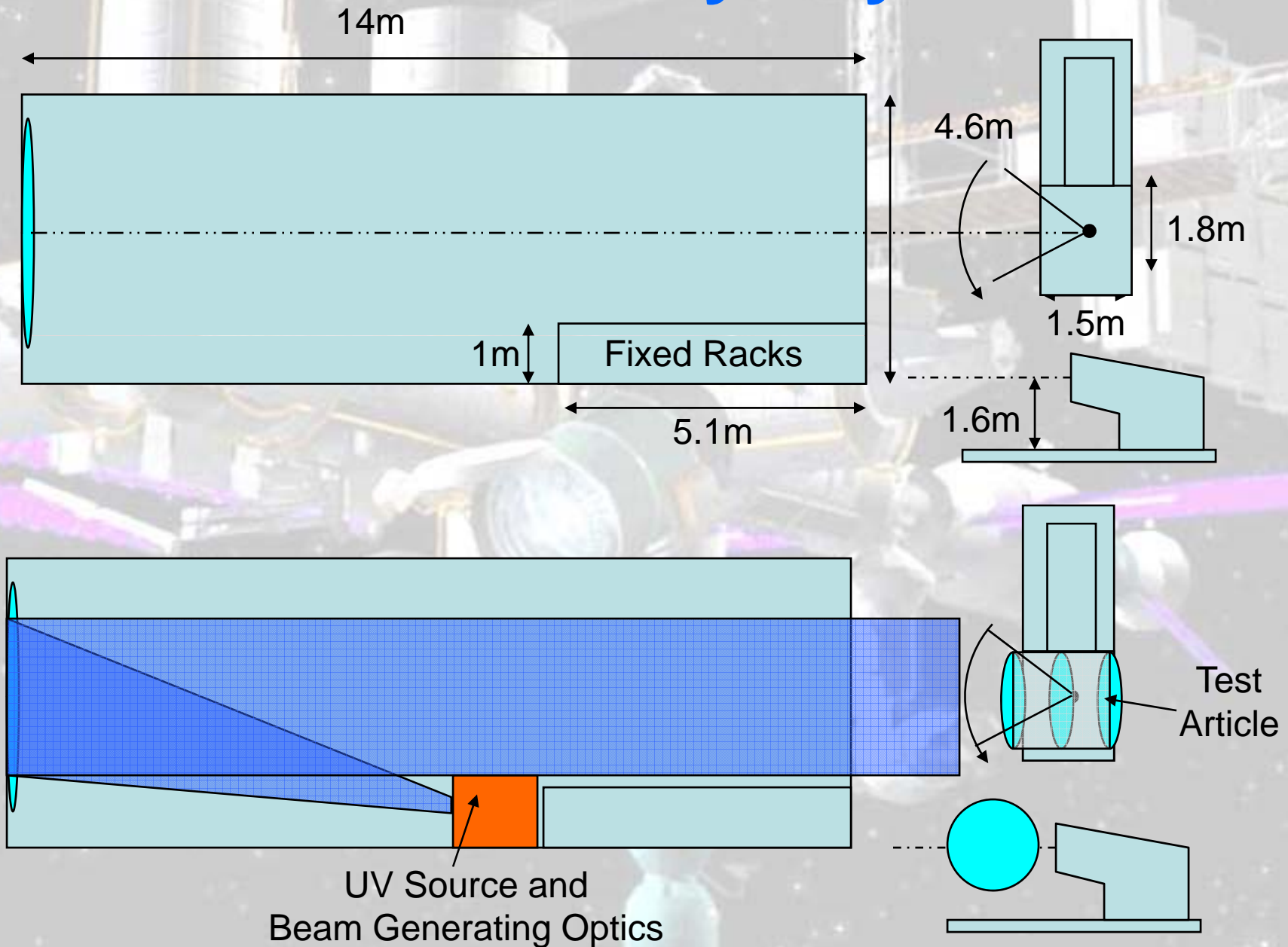
Technology Readiness Level (TRL)



Manufacture and test Prototype Sub-scale System

- **Central 1.0 to 1.5 meters of all three optical elements made from PMMA manufactured in Japan..**
- **Mounted to a metering structure the same way they are mounted for flight, but the metering structure will be fixed, not telescoping as the flight one.**
- **Optics prescription will be used in simulations to predict the performance of the optics in flight.**
- **The optics will be tested by illuminating the full aperture. The throughput and the spot size will be measured at a sampling of field angles from 0° to 30°.**
- **Results will be compared with the optical simulations in order to validate these models.**
- **The validated models can then be used to predict the performance of the full 2.5 meter diameter optical system.**

AMOR Facility Layout



Manufacture and test a full-scale single lens

- A demonstration part will be manufactured in Japan on one of the large Toshiba machines with a diameter of 2.5 meters. This will be a flat PMMA disk that is cut between 0.5 and 1.25 meters radius. The cut should demonstrate manufacturing the most difficult parts of the 2.5 meter Fresnel pattern and the blazed grating on the diffractive surface.
- Optical simulations, validated with the subscale prototype, will be used to determine the limits on manufacturing errors (tolerances) that will result in optics that meet EUSO's requirements. There will be limits on surface roughness (or errors at high spatial frequency); radial and azimuthal slope errors (at lower spatial frequencies) and plunge cut depth errors in the blazed grating.
- The demonstration part will be measured to determine whether it was made within the allowable tolerances.

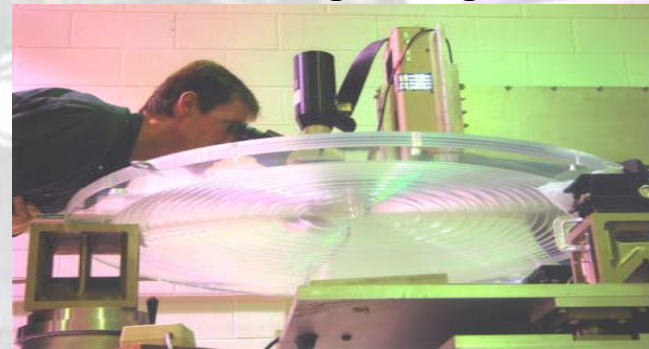
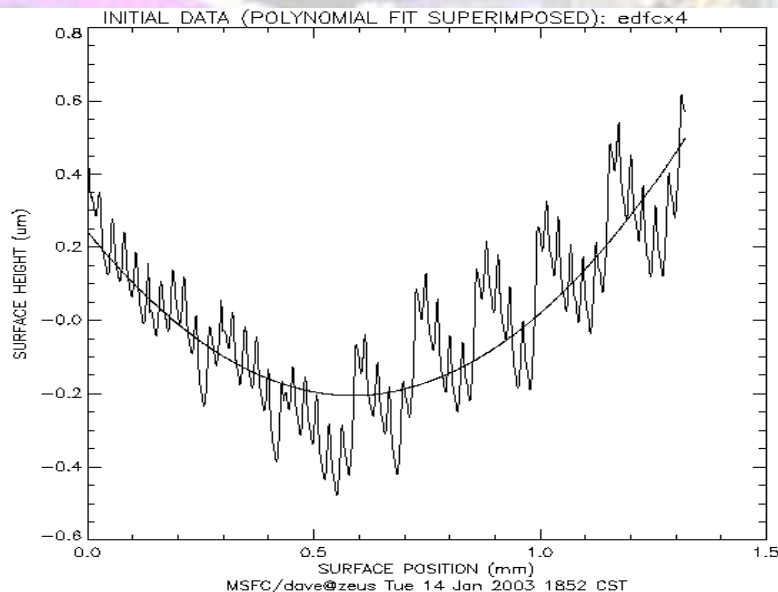
Metrology

On the Fresnel surfaces we will measure:

- The surface roughness, which we expect to be in the 10 nm rms range.
- The local profiles of the Fresnel surfaces in the radial and azimuthal directions over distances of the order of the width of a Fresnel zone.
- The root and tip radii at the Fresnel backcuts.

On the Diffractive surface we will measure:

- The surface roughness, which we expect to be in the 10 nm rms range.
- The root and tip radii at the blazed grating backcuts.
- The local plunge depth irregularity at the blazed grating backcuts.



1m Double Fresnel

| Zone | Radial | Tangential |
|--------|---------------|--------------|
| Center | 1210 (edfcx4) | 624 (edfcx3) |
| Edge | 416 (edfcx2) | 114 (edfcx1) |

(Units are
Angstroms
RMS)

Anti-Reflective Coating

- Small Business contract to test and demonstrate new technique
- AR coating based on nano-particle technology
- Small scale test articles have been demonstrated
- Tunable index of refraction and thickness of coating
- Suitable for near UV
- Adheres to PMMA

